What is Claimed:

1. A method for controlling a shape of an area laser machined by a pulse of laser light on a surface of a workpiece to be a predetermined elliptical shape with a predetermined major axis aligned in a predetermined direction, the predetermined major axis having a predetermined major axis length less than or equal to a diameter of a beam spot of the pulse of laser light, the method comprising the steps of:

a) generating the pulse of laser light;

b) focusing the pulse of laser light to the beam spot within a target area of the microstructure workpiece;

c) adjusting a polarization of the pulse of laser light such that in the beam spot the pulse of laser light is elliptically polarized and an axis of a polarization ellipse of the pulse of laser light is oriented in the predetermined direction;

d) adjusting an ellipticity of the polarization of the pulse of laser light such that the pulse of laser light has contours of constant machining capacity on the surface of the microstructure workpiece, the constant machining capacity contours having a substantially similar shape to the predetermined elliptical shape;

e) controlling fluence of the focused pulse of laser light in the beam spot such that the area of the surface of the workpiece laser machined by the pulse of laser light is substantially the predetermined elliptical shape.

2. The method according to claim 1, wherein the diameter of the beam spot is substantially diffraction limited.

3. The method according to claim 1, wherein step (c) includes adjusting the polarization of the pulse of laser light such that, in the beam spot, the pulse of laser light is linearly polarized in the predetermined direction.

4. A method for laser machining a feature on a surface of a microstructure workpiece, the feature having a variable, submicron width substantially perpendicular to a center line of the feature, the method comprising the steps of:

a) generating a plurality of pulses of laser light;

b) focusing the plurality of pulses of laser light to a beam spot within a target area of the microstructure workpiece;

c) controlling fluence of the beam spot in the target area of the workpiece such that a diameter of a area of the target area machined by a circularly polarized pulse of the plurality of pulses of laser light is substantially equal to a minimum width of the feature perpendicular to the center line;

d) controlling a position of a center of the beam spot within the target area so as to follow the center line of the feature; and

e) controlling a polarization of the plurality of focused pulses of laser light incident on the microstructure workpiece such that an area of the surface of the microstructure workpiece machined by one pulse of laser light has a substantially elliptical shape with a major axis substantially perpendicular to the center line at an incidence point of the center line corresponding to the center of the beam spot for the one pulse, and a length of the major axis of the substantially elliptical shape is substantially equal to a width of the feature perpendicular to the center line at the incidence point.

5. The method according to claim 4, wherein the microstructure workpiece is used in manufacturing of at least one of a microstructure mold, a quantum cellular automaton, a coupled quantum dot device, a resonant tunneling device, a multifunction optical array, a diffractive optical element, a beam shaper, a microlens array, an optical diffuser, a beam splitter, a laser diode corrector, a fine pitch grating, a planar waveguide device, a photonic crystal, a micro-electrical-mechanical system, micro-circuitry, a micro-surface-acoustic-wave device, a micro-mechanical oscillator, a polymerase chain reaction microsystem, a biochip for detection of hazardous chemical and biological agents, or a high-throughput drug screening and selection microsystem.

6. The method according to claim 4, wherein step (d) further comprises the step of controlling the position of the center of the beam spot within the target area with an accuracy of less than about 100nm.

7. The method according to claim 4, wherein:

the plurality of pulses of laser light propagate along a beam path including a transversely moveable pinhole mask having a pinhole located in the beam path;

step (b) includes focusing the plurality of pulses of laser light such that a beam spot diameter of the beam spot within the target area of the workpiece is smaller than a pinhole diameter of the pinhole; and

step (d) includes controlling the position of the center of the beam spot within the target area by moving the transversely moveable pinhole mask a scaled amount based on a ratio of the pinhole diameter to the beam spot diameter.

8. The method according to claim 4, wherein step (d) includes controlling the position of the center of the beam spot within the target area of the microstructure workpiece by moving the microstructure workpiece.

9. The method according to claim 4, wherein step (a) includes generating the plurality of pulses of laser light using one of an ultrafast laser or a pulsed excimer laser.

10. The method according to claim 4, wherein machining the feature on the surface of the microstructure workpiece includes one of:

ablating workpiece material of the microstructure workpiece;

laser chemical vapor depositing deposition material on the surface of the microstructure workpiece;

exposing photoresist on the surface of the microstructure workpiece;

changing an index of refraction of workpiece material of the microstructure workpiece;

altering a lattice structure of workpiece material of the microstructure workpiece; or

changing a chemical composition of workpiece material of the microstructure workpiece.

11. The method according to claim 4, wherein the center line of the feature includes a curved portion.

12. The method according to claim 4, wherein a depth of material of the microstructure workpiece machined by each pulse of the plurality of pulses of laser light is substantially constant.

13. A method for laser machining a feature within a substantially transmissive microstructure workpiece, the feature having a substantially elliptical cross-section perpendicular to a center line of the feature, the method comprising the steps of:

a) generating a plurality of pulses of laser light;

b) focusing the plurality of pulses of laser light to form a beam waist within a target area of the substantially transmissive microstructure workpiece;

c) controlling an alignment and a position of the beam waist within the target area such that a direction of propagation of each pulse of the plurality of pulses of laser light is substantially parallel to the center line of the feature at a point on the center line corresponding to a center of the beam waist as the center of the beam waist substantially follows the center line from a first end to a second end;

d) controlling a polarization of one pulse of the plurality of pulses of laser light within the target area of the microstructure workpiece such that the one pulse has surfaces of constant machining capacity in the beam waist, and the constant

machining capacity surfaces have a cross-sectional shape perpendicular to the direction of propagation of the one pulse which is substantially confocal to the substantially elliptical cross-section of the feature at the point on the center line corresponding to the center of the beam waist during the one pulse; and

e) controlling a fluence of the one pulse in the beam waist such that a region of the target area machined by the one pulse substantially matches the substantially elliptical cross-section of the feature perpendicular to the center line at the point corresponding to the center of the beam waist.

14. The method according to claim 13, wherein the substantially transmissive microstructure workpiece is used in manufacturing of at least one of a quantum cellular automaton, a coupled quantum dot device, a resonant tunneling device, a multifunction optical array, a diffractive optical element, a beam shaper, a microlens array, an optical diffuser, a beam splitter, a laser diode corrector, a fine pitch grating, a waveguide device, a photonic crystal, a micro-electrical-mechanical system, micro-circuitry, a micro-mechanical oscillator, a polymerase chain reaction microsystem, a biochip for detection of hazardous chemical and biological agents, or a high-throughput drug screening and selection microsystem.

15. The method according to claim 13, wherein step (c) further comprises the step of controlling the position of the center of the beam waist within the target area with an accuracy of less than about 100nm.

16. The method according to claim 13, wherein step (c) includes controlling the alignment and the position of the center of the beam waist within the target area of the substantially transmissive microstructure workpiece by moving the substantially transmissive microstructure workpiece.

17. The method according to claim 13, wherein step (a) includes generating the plurality of pulses of laser light using one of an ultrafast laser or a pulsed excimer laser.

18. The method according to claim 13, wherein machining the feature within the substantially transmissive microstructure workpiece includes at least one of:

changing the index of refraction of material of the substantially transmissive microstructure workpiece;

altering the lattice structure of material of the substantially transmissive microstructure workpiece; or

changing the chemical composition of material of the substantially transmissive microstructure workpiece.

19. The method according to claim 13, wherein the center line of the feature includes a curved portion.

20. The method according to claim 13, wherein:

the feature is a waveguide;

the first end of the center line of the feature is on a back surface of the substantially transmissive microstructure workpiece; and

the second end of the center line of the feature is on a front surface of the substantially transmissive microstructure workpiece.

21. The method according to claim 20, wherein the waveguide includes at least one beam mode expansion section.

22. The method according to claim 20, wherein the waveguide includes at least one polarization shifting section.

23. A method for storing data on a surface with a plurality of marks formed by laser machining, each of the plurality of marks having a predetermined elliptical shape with a shape major axis aligned in one of a respective predetermined number of

directions, the predetermined number being greater than one, the method comprising the steps of:

a) encoding the data into a sequence of directions selected from the predetermined number of directions;

b) generating and focusing a plurality of pulses of laser light to form a beam spot on the surface;

c) adjusting polarization and fluence of the plurality of focused pulses of laser light incident on the surface such that each pulse of the plurality of pulses of laser light has a polarization ellipse with a predetermined ellipticity greater than zero and an area of the surface laser machined by each pulse of the plurality of pulses of laser light is substantially the predetermined elliptical shape;

d) scanning the beam spot across the surface such that each focused pulse of the plurality of pulses of laser light machines a separate position on the surface;

e) rotating the polarization ellipse of the plurality of focused pulses of laser light incident on the surface such that a polarization major axis of the polarization ellipse of each focused pulse of the plurality of pulses of laser light is substantially aligned, in sequence, to one of the predetermined number of directions corresponding to one of the sequence of directions encoded in step (a) to represent the data.

24. The method according to claim 23, wherein the predetermined number of directions is a power of two.

25. The method according to claim 23, wherein the predetermined ellipticity of the polarization ellipse is approximately one.

26. The method according to claim 23, wherein a length of the shape major axis is less than a peak wavelength of the plurality of pulses of laser light.

27. A method for storing data on a surface with a plurality of marks formed by laser machining, each of the plurality of marks having an elliptical shape with a shape axis aligned in a predetermined direction and an ellipticity selected from a respective predetermined number of ellipticities, the predetermined number being greater than one, the method comprising the steps of:

a) encoding the data into a sequence of ellipticities selected from the predetermined number of ellipticities;

b) generating and focusing a plurality of pulses of laser light to form a beam spot on the surface;

c) adjusting polarization and fluence of the plurality of focused pulses of laser light incident on the surface such that each pulse of the plurality of pulses of laser light has a polarization ellipse with a polarization major axis aligned to the predetermined direction;

d) scanning the beam spot across the surface such that each focused pulse of the plurality of pulses of laser light machines a separate position on the surface;

e) changing an ellipticity of the polarization ellipse of the plurality of focused pulses of laser light incident on the surface such that a polarization ellipticity of the polarization ellipse of each focused pulse of the plurality of pulses of laser light is substantially set, in sequence, to one of the predetermined number of ellipticities corresponding to one of the sequence of ellipticities encoded in step (a) to represent the data.